

Microchiropteran fauna of Kroombit Tops, central Queensland, including a discussion on survey techniques

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ABSTRACT

A survey of the microchiropteran fauna of Kroombit Tops, central Queensland identified a total of twenty species. This survey recorded nine additional species to previous surveys due to a greater survey effort, sampling in remote areas away from access roads and employing an additional survey technique, roost location. Three techniques were used: trapping using harp trap and tripline methods; ultrasonic detection using hand-held, driving transect and remote sensing techniques; and roost location. No single survey technique recorded all 20 species of bats. A number of significant findings were made, including a southerly range extension of Semon's Leaf-nosed Bat *Hipposideros semoni* and a record of the Golden-tipped Bat *Kerivoula papuensis* in riparian vegetation in dry forest. A discussion on the value of employing a variety of techniques in a microchiropteran survey is presented.

INTRODUCTION

There have been two previous surveys of the bat fauna of the Kroombit Tops area. Woodall (1986) provided a list of mammals of the area compiled during a field excursion by the Queensland Naturalist's Club in December 1983. In this survey no specific attempts were made to survey bats and museum specimens were used to provide a list of bat species. From this survey a total of four microchiropteran species were listed for Kroombit Tops, representing 14% of the 28 species of mammals recorded for the area (Woodall 1986).

In April 1992 a survey over three nights employing both trapping and ultrasonic detection techniques revealed 10 species of bats in the area (Rhodes *et al.* 1993), including the capture of three Golden-tipped Bats *Kerivoula papuensis*, a species rarely recorded throughout its range (Richards 1983). This survey provided an additional seven species to the list of bats detailed by Woodall (1986).

A survey of the microchiropteran fauna of Kroombit Tops, central Queensland, was undertaken in 1994 as part of a vertebrate fauna survey of the Kroombit Tops State Forest by the Queensland Department of Primary Industries, Forestry. Although the two prior surveys had recorded eleven species of bats in the Kroombit Tops area, the present survey concentrated on the location of additional species. An examination of species' distribution maps in Hall and Richards (1979), Strahan (1983) and Ingram and Raven (1991) indicated that approximately 15 additional species of microchiropteran bats may potentially occur in the Kroombit Tops area.

STUDY AREA

Kroombit Tops is an area of mountainous State Forest and National Park, located approximately 590 km north-north-west of Brisbane and 85 km south-south-west of Gladstone at the junction of the Dawes, Calliope and Milton Ranges. Kroombit Tops lies generally above 800 m, reaching a maximum elevation of 938 m on the ridge between Kroombit and Dry Creek valleys (Fig. 1). The plateau is bounded on the north-east by a 400 to 500 m escarpment, with cliffs up to 50 m high along the Calliope and Dawes Range. In the west and south the plateau falls away in a series of narrow ridges and steep-sided valleys.

Kroombit Tops is situated in a subtropical zone, but it has been described as a "temperate island" due to its elevation (McDonald and Sharpe 1986). Precipitation is principally concentrated in the summer months and the humidity is relatively high. Summers are warm to hot while winters are fine and cool with frequent frosts (Department of Forestry 1987).

The vegetation of the area has been described by McDonald and Sharpe (1986) and the Department of Forestry (1987), as generally of three broad categories: sub tropical rainforest (4.2%), wet sclerophyll forest or tall open forest (18.8%), and dry sclerophyll forest or open forest (77%). This range of vegetation occurs in sheltered rainforest gullies, with tall open forest dominated by Sydney blue gum *Eucalyptus saligna* on adjacent slopes, and dry open forest on the stony soils of the ridge tops which are dominated by white mahogany *E. acmenoides*.

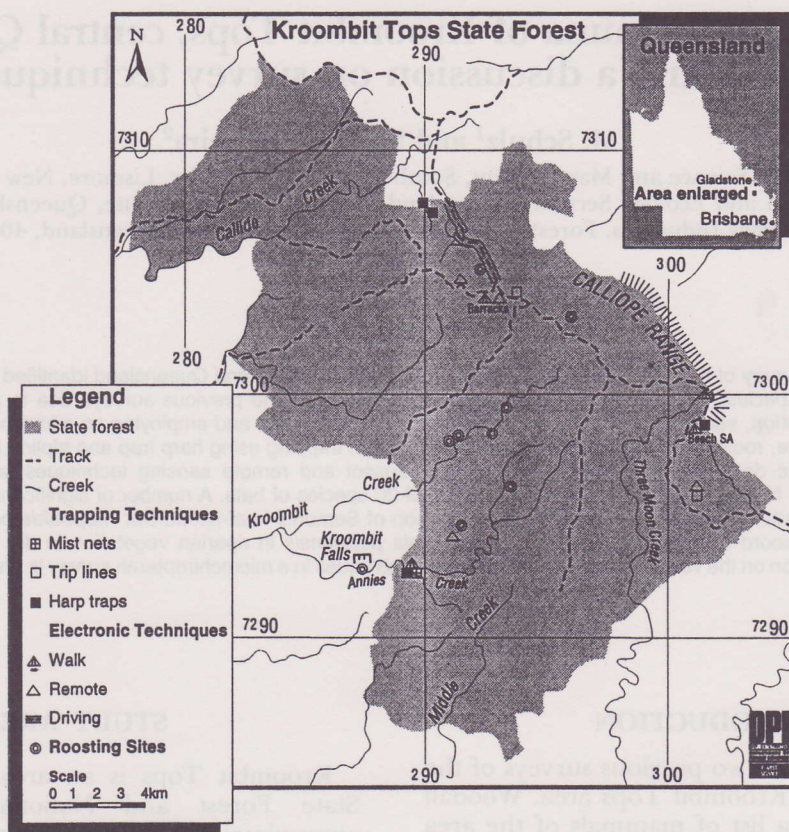


Fig. 1. Kroombit Tops survey sites.

METHODS

The microchiropteran fauna present in Kroombit Tops was surveyed during two field trips to the area (7–14 March 1994 and 22–28 March 1994), three principal techniques were employed to survey the bat fauna:

1. **Trapping** — A total of 77 harp trap nights using both standard (trapping area: height 1.0 m, width 1.8 m) and mini harp traps (trapping area: height 2.4 m, width 1.8 m) designed by Ausbat (Victoria), based on modifications of the designs of Tuttle (1974) and Tidemann and Woodside (1978), were deployed at five sites (Fig. 1). Two monofilament mistnets were used as “wings” to the harp trap set adjacent to Annies Creek (Fig. 1). A total of nine tripline hours (refer to Helman and Churchill 1986) using 4 kg breaking strength fishing line (0.25 mm diameter) was spent at two stock dams (Fig. 1).
2. **Ultrasonic detection** — Ultrasonic signals of free-flying bats were recorded using the Anabat II bat detector system (Titley Electronics, Ballina, New South Wales) (Corben 1989; de Oliveira *et al.* 1994). Echolocation calls were recorded on a tape recorder (Realistic VSC-2001). Signals were analysed using zero-crossing analysis with Anabat dedicated software on an IBM computer. Parameters used for species

identifications were: frequency, pulse duration, interpulse interval and shape (Corben 1989 and de Oliveira *et al.* 1994). The main features of most of the echolocation calls of species identified in this survey by ultrasonic detection are detailed in Jones and Corben (1993). Anabat II was deployed in three ways:

- a. **Hand-held**: approximately 7.5 hours were spent walking with the bat detector connected to a portable tape recorder at four sites (Fig. 1).
 - b. **Driving Transect**: approximately 1.2 hours were spent recording ultrasonic calls while driving on pre-determined routes at speeds of between 25 and 30 km/h (Fig. 1).
 - c. **Remote sensing**: approximately 52 hours of recordings were made at four sites (Fig. 1). Overnight sampling of ultrasonic bat calls was made by two or three sets of equipment consisting of a bat detector connected to a voice actuated tape recorder, enclosed in a protective plastic container. The tape recorder was automatically triggered by the detector's incoming signals (de Oliveira and Pavey 1995).
3. **Roost Location** — particular effort was devoted to this technique due to the extensive expanses of rock face and overhangs present in the area and the potential for locating

Table 1. Bats recorded at Kroombit Tops in March 1994 using three principal survey methods.

Species		Survey Methods			
		Trapping techniques			Roost site location
		Harp traps	Trip lines	Σ	
Eastern Horseshoe Bat	<i>Rhinolophus megaphyllus</i>	13	—	13	+
Semon's Leaf-nosed Bat	<i>Hipposideros semoni</i>	—	—	—	—B
Common Sheath-tail-bat	<i>Taphozous georgianus</i>	—	—	—	*
White-striped Freetail Bat	<i>Tadarida australis</i>	—	1	1	—A
Little Freetail Bat	<i>Mormopterus loriae</i>	—	10	10	*C
Beccari's Freetail Bat	<i>Mormopterus beccarii</i>	—	1	1	—A
Gould's Long-eared Bat	<i>Nyctophilus gouldi</i>	4	—	4	*
Lesser Long-eared Bat	<i>Nyctophilus geoffroyi</i>	2	—	2	*
Northern Long-eared Bat	<i>Nyctophilus bifax</i>	21	—	21	*
Common Bent-wing Bat	<i>Miniopterus schreibersii</i>	4	—	4	+
Little Bent-wing Bat	<i>Miniopterus australis</i>	3	—	3	+
Gould's Wattled Bat	<i>Chalinolobus gouldii</i>	1	3	4	+
Chocolate Wattled Bat	<i>Chalinolobus morio</i>	1	3	4	—A
Hoary Wattled Bat	<i>Chalinolobus nigrogriseus</i>	1	—	1	—A
Large-footed Myotis	<i>Myotis moluccarum</i>	—	—	—	—A
Greater Broad-nosed Bat	<i>Scoteanax rueppellii</i>	—	2	2	—A
Broad-nosed Bat	<i>Scotorepens</i> spp.	1	—	1	—C
Golden-tipped Bat	<i>Kerivoula papuensis</i>	4	—	4	—B
Eastern Forest Bat	<i>Vespadelus pumilus</i>	25	—	25	+
Eastern Cave Bat	<i>Vespadelus troughtoni</i>	4	—	4	*
TOTAL SPECIES:	20	13	6	17	5
					10

For roost location, the number of located sites is provided. Common names after Richards *et al.* (1993).

**located by radio telemetry only

For ultrasonic detection the three techniques have been combined and no attempt was made to score individual passes, species were either detected and identified (+), not detected (—), or detected but awaiting verification (*). Additional symbols refer to current understanding of species' ultrasound identification in Southern Queensland, after Corben (1989), Jones and Corben (1993) and de Oliveira *et al.* (1994):

A — sound knowledge; B — poor knowledge; C — awaits taxonomic clarification.

previously unrecorded cave-dwelling bat roost sites (Fig. 1). A total of 82 hours was spent searching for potential roost sites in escarpment areas, bases of cliff lines, overhangs, at the base of waterfalls and along creeklines. In addition, local forestry workers, bushwalkers and adjacent landholders were questioned about any roost sites of bats that they may have encountered in the region.

RESULTS

A total of 20 microchiropteran species was recorded in the survey, comprising 36% of the total 55 mammal species detected in the Kroombit Tops area (Schulz 1994).

Seventeen species were recorded by trapping methods (Table 1). Species detected by trapping methods alone were the White-striped Freetail Bat *Tadarida australis*, Gould's Long-eared Bat *Nyctophilus gouldi*, Lesser Long-eared Bat *N. geoffroyi*, Hoary Wattled Bat *Chalinolobus nigrogriseus*, Greater Broad-nosed Bat *Scoteanax rueppellii*, Broad-nosed Bat *Scotorepens* spp. and the Golden-tipped Bat *Kerivoula papuensis*. Two species were recorded using only the tripline trapping technique and five species using the harp trap technique (Table 1). No species were captured in the two mist nets set as "wings" to a harp trap in Annies Creek.

Analysis of the ultrasound recordings revealed 11 species of bats, of which only five were conclusively identified (Table 1 indicated as +). All five species were located using one or more of the other survey strategies employed. Electronic survey of micro-bats in Australia is a relatively new but rapidly evolving method. Currently, it is not possible to identify all genera to species level (de Oliveira *et al.* 1994). Refer to the discussion for current understanding in Southern Queensland of echolocation calls and species identification based on their ultrasound.

Nine species were recorded by locating roost sites, including three species not detected with the other survey methods (Table 1). These were Semon's Leaf-nosed Bat *Hipposideros semoni*, Common Sheath-tail-bat *Taphozous georgianus*, and the Large-footed Myotis *Myotis moluccarum*.

The roost location technique revealed a low return for search effort, with 0.2 roost sites located per search hour (all species combined). However it revealed two previously unknown, important caves for roosting bats (L. Hall, Univ. of Queensland, pers. comm.). One cave located on Kroombit Creek contained four species of bats. Including two Semon's Leaf-nosed Bats *Hipposideros semoni* (one male and one female), a significant record representing a range extension for this species. The nearest known records are

from the Townsville region (L. Hall, Univ. of Queensland, pers. comm.). This cave also contained large numbers of three other species: 8 000+ Little Bent-wing Bats *Miniopterus australis*, 2 000+ Common Bent-wing Bats *Miniopterus schreibersii* and 70+ Eastern Horseshoe Bats *Rhinolophus megaphyllus*. One roost site containing four species of bats at the base of Upper Kroombit Falls was visited following discussions with local bushwalkers. This cave contained an adult female Common Sheath-tail-bat *Taphozous georgianus*; this is at the southern range limit for this species (Hall and Richards 1979; Ingram and Raven 1991). Three other bat species also occurred in this cave: 1 500+ Common Bent-wing Bats, 800+ Little Bent-wing Bats and two Large-footed *Myotis*.

Two additional Large-footed *Myotis* were found roosting in a small hole (entrance dimensions: 6 × 4 cm, depth >0.5 m) situated on a steeply sloping rock face 1.5 m above a deep pool on Kroombit Creek. This roost was located from the water by checking cracks and crevices in vertical rock faces in a deep gorge with a waterproofed Petzl headlamp. Numerous other holes, cracks and crevices were checked along Kroombit Creek and other watercourses without finding additional roost sites of this species.

Incidental location of two species of tree-dwelling bats was made during the course of the survey — one Northern Long-eared Bat *Nyctophilus bifax* was flushed from a dense accumulation of hanging dead fronds of a Prickly Tree Fern *Cyathea leichhardtiana* in rainforest adjacent to Three Moon Creek. A minimum of six individuals of the Chocolate Wattled Bat *Chalinolobus morio* were flushed from a hollowed-out New England Blackbutt *Eucalyptus andrewsii* three metres above the ground in the Kroombit Scientific Area.

The Eastern Cave Bat *Vespadelus troughtoni* was located roosting in three sites. Two of these were day roost sites in large overhangs with northerly aspects at the bases of cliff lines. Both roost sites were in semi-dark situations, the first supporting six individuals and the second four individuals (two males and two females). A single individual was located roosting in a boulder overhang with a north-east aspect on a small rock outcrop at 0030 hours in cool rainy conditions on 8 March 1994.

Three Golden-tipped Bats were captured over 44 harp trap nights in the Beech Scientific Area (Fig. 1) in rainforest dominated by Jackwood *Cryptocarya glaucescens*, *Sloanea woollsii*, Coachwood *Ceratopetalum apetalum*, Rose Walnut *Endiandra sieberi*, *Eleocarpus grandis*, Coogera *Arytera lautereriana* and Soft Corkwood *Caldcluvia paniculosa*. This was the same locality in which

three individuals were captured over 14 harp trap nights in April 1992 (Rhodes *et al.* 1993).

A transmitter weighing 0.48 g (Titley Electronics, Ballina) was attached to a male Golden-tipped Bat in this site to determine its roost site location. This individual roosted on three consecutive nights in the trunk of an *Endiandra sieberi* that had broken off 5 m above the ground (Schulz, unpubl. records). The trunk was hollowed out and the bat was roosting near the top of the tree inside the hollow. This roost site was located 468 m from where the bat was trapped.

Another Golden-tipped Bat was trapped on Callide Creek in dry open forest on the 12 March 1994. This bat is typically regarded as a rainforest species (e.g., Richards 1983), although individuals have been recorded in temperate dry eucalypt forest in Mumbulla State Forest (Lunney and Barker 1986) and in regrowth dry sclerophyll forest in Badja State Forest (Parnaby and Mills 1994) on the south coast of New South Wales. The riparian vegetation was dominated by River Sheoak *Allocasuarina cunninghamiana* and Bottlebrush *Callistemon* spp. with some stands of Lantana *Lantana* spp. The creek was bordered by dry sclerophyll forest, dominated by Forest Red Gum *Eucalyptus tereticornis*, White Mahogany *E. acmenoides*, Smooth-barked Apple *Angophora costata* and Spotted Gum *E. maculata*. Approximately 320 m upstream from this site was a narrow riparian band of Araucarian microphyll vine forest. In the second March survey, no further Golden-tipped Bats were caught in this site over 17 harp trap nights or in the upstream Araucarian microphyll vine forest over nine harp trap nights. This result may in part be attributed to the weather conditions during this survey period, comprising constant strong winds over ten knots, near full moon, showers and cold conditions with dusk temperatures typically below 17°C.

DISCUSSION

The present survey included all species previously found by Woodall (1986) and Rhodes *et al.* (1993) and added an additional nine species of bats: Semon's Leaf-nosed Bat *Hipposideros semoni*, Common Sheath-tail-bat *Taphozous georgianus*, Little Freetail Bat *Mormopterus loriae*, Beccari's Freetail Bat *Mormopterus beccarii*, Gould's Long-eared Bat *Nyctophilus gouldi*, Lesser Long-eared Bat *Nyctophilus geoffroyi*, Large-footed *Myotis* *Myotis moluccarum*, Broad-nosed Bat *Scotorepens* sp. and the Eastern Cave Bat *Vespadelus troughtoni*.

The reasons for the additional species include a greater survey effort: more trapping, location of sampling sites away from access roads and tracks, sampling a greater altitudinal range and

employing the additional survey technique of roost location. For example, no specific bat trapping was conducted by Woodall (1986) in the 1983 survey and in Rhodes *et al.* (1993) a total of fourteen harp trap nights was sampled on the edge of forestry roads in April 1992.

To adequately survey an area for bats it is important to employ a number of sampling techniques and a range of methods. No single technique during the present survey recorded all the bat species present in the area. The roost location technique, although time consuming and providing a low return (0.2 roost sites/search hour), located three species not detected by other survey techniques and provided significant new information. Ultrasonic detection did not record additional species but provided an opportunity for sampling of sites otherwise not surveyed.

Detailed accounts of the main features of free-flying echolocation calls of most micro-bats in Australia is still largely unpublished. This fact added to the need of further investigation of echolocation calls and taxonomic clarification of some species results in conservative ultrasound identification. These and other factors influencing the identifications for this survey are discussed as follows:

1. Since this microchiropteran survey formed only a part of the vertebrate fauna survey of the Kroombit Tops State Forest (Schulz 1994), only a limited amount of time was available to undertake ultrasonic detection using the hand-held and driving transect techniques. Six species (Table 1, indicated as A) recorded by other techniques were not detected by ultrasonic means. The ultrasound of these species would have readily been detected and conclusively identified in the present survey. The limited time available for deploying ultrasonic detection resulted in predominantly using the remote sensing technique. This technique had limitations in that on some occasions insect noise would activate and waste tape time, with no bat ultrasound recorded. More importantly the technique was limited by weather, with no remote sensing undertaken when there was a high probability of rain. Under such conditions sampling was only possible using the protection of the verandah of the Forestry barracks and suitable rock shelters. To be effective and independent of weather conditions a water-proof cover such as a mini-tent over the equipment is required. Voice actuated remote sensing was used due to unavailability of other remote sensing equipment commonly deployed by QDPI Forestry Staff, consisting of a bat detector connected to a Delay Switch (Titley Electronics, Ballina) and a tape recorder. The Delay

Switch has two advantages over the Voice actuated technique, it deploys the bat detector's built-in calibration tone and provides the exact time each signal was received (de Oliveira and Pavey 1995).

2. Echolocation calls recorded by QDPI Forestry are maintained in a database which serve as a reference library. The library containing more than 14 000 calls is still incomplete, limiting the identification of some species. In the present survey this was the case for members of the genus *Nyctophilus*, Eastern Cave Bat *Vespadelus troughtoni* and Common Sheath-tail-bat *Taphozous georgianus*, which were commonly detected but can not be counted as identified until compilation of the call features and specific field work on these species is completed (Table 1, indicated as*).

Restrictions on bat ultrasound identification are compounded by currently unresolved taxonomic difficulties in a number of widespread genera, particularly the genera *Mormopterus* and *Scotorepens* (Parnaby 1991) (Table 1, indicated as C). For example, some calls of the genus *Mormopterus* ranging between 33 and 35 KHz were recorded in two sites during 7–14 March 1994 period. These calls are clearly different from other species of *Mormopterus* with which the authors are familiar. However, further investigation is required for conclusive identification. On the second trip 10 females caught by triplining at a stock dam near Clewleys Gap (Fig. 1) were keyed to *M. loriae* using the key of Hall and Richards (1979). These *Mormopterus* had grey-brown dorsal fur with white bases to the hair, the forearm ranged from 32.2 to 33.8 mm and the weight ranged from 7.9 to 9.6 g. No satisfactory ultrasonic recordings of these triplined individuals were possible due to incorrect setting of equipment.

Very little is known about the echolocation calls of *Kerivoula papuensis* and *Hipposideros semoni* (Table 1, indicated as B).

4. Incorrect setting of electronic equipment for a variety of reasons is not an uncommon practice as part of any evolving process. This results in the potential loss of detecting additional species. Incorrect setting of equipment occurred in one remote sensing session due to one person concurrently attempting to trap and detect ultrasounds; and during the driving transect due to the use of an inappropriate cable.

It is likely that with further survey work at other times of the year, such as in late spring and early autumn, additional species of microchiropteran may be recorded. Maps of species distribution shown in Hall and Richards (1979), Strahan (1983) and Ingram and Raven (1991)

indicate that one additional species, the Yellow-bellied Sheath-tail-bat *Saccolaimus flaviventris* could occur in the area.

CONCLUSION

The combination of survey techniques employed in this study resulted in the following significant new information:

- Two nationally rare and threatened bat species were recorded (following Richards and Hall 1994). These were the Semon's Leaf-nosed Bat (listed as rare) and the Golden-tipped Bat (listed as rare). The former species was detected by roost location and the latter species by trapping techniques.
- A significant southerly range extension of Semon's Leaf-nosed Bat from the nearest previously known locality in the Townsville area (Richards and Hall 1994; L. Hall, Univ. of Queensland pers. comm.).
- A record of the Golden-tipped Bat in a narrow band of riparian vegetation in dry sclerophyll forest. This species is typically regarded as a rainforest species (e.g., Richards 1983; Richards and Hall 1994), although previously four individuals have been trapped in dry sclerophyll forest in southern New South Wales (Lunney and Barker 1986; Parnaby and Mills 1994). Its presence in such a dry habitat was unexpected.
- The roosting of the Golden-tipped Bat in a broken off trunk of an *Endiandra sieberi*. This species has not previously been recorded roosting in tree hollows (Schulz 1995; Schulz, unpubl. records). This roost site was discovered through the use of a transmitter attached to the bat.
- The location of two large previously unknown *Miniopterus* roost sites totalling 8 800+ Little Bent-wing Bats and 3 500+ Common Bent-wing Bats.
- The location of three Eastern Cave Bat roost sites; few roost sites of this species are known from southern Queensland (L. Hall, Univ. of Queensland, unpubl. records).
- The location of a single Northern Long-eared Bat roosting in a dense accumulation of hanging dead fronds of a tree fern. This bat has been recorded roosting in a number of situations, particularly in rainforest foliage (Lunney *et al.* 1995; Schulz, unpubl. records). The authors are unaware of this or other bat species have been previously encountered roosting in tree ferns.
- The location of a Common Sheath-tail-bat roost site at the southern edge of this species range (Hall and Richards 1979; Ingram and Raven 1991).

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REFERENCES

- Corben, C., 1989 Computer-based call analysis for microbat identification. Eighth International Bat Research Conference Sydney, Australia, 9–15 July 1989. Abstracts. *Macroderma* 5: 7.
- de Oliveira, M. C., Corben, C. and Hogan, L. D., 1994. Ultrasonic detection of Micro-bats in South-east Queensland. Queensland Department of Primary Industries, Forest Service, Fauna Conservation and Ecology Section. Internal Report and Future Directions. Draft April 1994.
- de Oliveira, M. C. and Pavey, C. R., 1995. In search of *Hipposideros semoni* at St Mary's State Forest, South-east Queensland. *Austral. Bat Soc. News*. 4: 46–48.
- Department of Forestry, 1987. *Kroombit Tops Management Plan*. Department of Forestry: Queensland.
- Hall, L. S., 1983 Greater Wart-nosed Horseshoe-bat *Hipposideros semoni*. In *Complete Book of Australian Mammals* ed by R. Strahan. Angus and Robertson: Sydney.
- Hall, L. S. and Richards, G. C., 1979. *Bats of Eastern Australia*. Qld. Mus. Booklet No. 12, Queensland Museum: Brisbane.
- Helman, P. and Churchill, S., 1986. Bat capture techniques and their use in surveys. *Macroderma* 2: 32–53.
- Ingram, G. J. and Raven, R. J. (eds) 1991. *An Atlas of Queensland's Frogs, Reptiles, Birds and Mammals*. Queensland Museum: Brisbane.
- Jones, G. and Corben, C., 1993. Echolocation calls from six species of microchiropteran bats in southeastern Queensland. *Aust. Mammal.* 16: 35–38.
- Lunney, D. and Barker, J., 1986. The occurrence of *Phoniscus papuensis* (Dobson) (Chiroptera: Vespertilionidae) on the south coast of New South Wales. *Aust. Mammal.* 9: 57–58.
- Lunney, D., Barker, J., Leary, T., Priddel, D., Wheeler, R., O'Connor P. and Law, B., 1995. Roost site selection by the North Queensland Long-eared Bat *Nyctophilus bifax* Thomas, 1915 (Chiroptera: Vespertilionidae) in littoral rainforest on the north coast of New South Wales. *Aust. J. Ecol.* in press.
- McDonald, W. J. F. and Sharpe, P. R., 1986. The plant communities and flora of Kroombit Tops. *Qld Nat.* 27: 3–10.
- Parnaby, H., 1991. A sound species taxonomy is crucial to the conservation of forest bats. Pp. 101–12 in *Conservation of Australia's Forest Fauna* ed by D. Lunney. Royal Zool. Soc. New South Wales: Mosman.
- Parnaby, H., 1992. An interim guide to identification of insectivorous bats of southeastern Australia. *Tech. Reports. Aust. Mus.* 8: 1–33.
- Parnaby, H. and Mills, D., 1994. A record of the Gold-tipped Bat from the escarpment forests of southern New South Wales. *Aust. Zool.* 29: 245–49.

- Rhodes, M. P., Corben, C., Hall, L. S. and de Oliveira, M. C., 1993. The bat fauna of Kroombit Tops. *Qld Nat.* **32**: 18–21.
- Richards, G., Hall, L., Hoyer, G., Lumsden, L., Parnaby, H., Reardon, T., Strahan, R., Thomson, B. and Tidemann, C., 1993. A revision of the inventory and English names of Australian bats. *Austral. Bat Soc. News.* **2**: 8–15.
- Richards, G. C., 1983. Golden-tipped Bat *Phoniscus papuensis*. Pp. 355 in *Complete Book of Australian Mammals* ed by R. Strahan. Angus and Robertson: Sydney.
- Richards, G. C. and Hall, L. S., 1994. *An Action Plan for Bat Conservation in Australia*. Draft. Aust. Nature Conservation Agency: Canberra.
- Schulz, M., 1994. *The Fauna of Kroombit Tops State Forest*. Internal Report, Queensland Forest Service: Brisbane.
- Schulz, M., 1995. Utilization of suspended bird nests by the Golden-tipped Bat (*Kerivoula papuensis*) in Australia. *Mammalia* **59**: 280–83.
- Strahan R. (ed.) 1983. *Complete Book of Australian Mammals*. Angus and Robertson: Sydney.
- Tidemann, C. R. and Woodside, D. P., 1978. A collapsible bat trap and a comparison of results obtained with the trap and mist nets. *Aust. Wildl. Res.* **5**: 355–62.
- Tuttle, M. D., 1974. An improved trap for bats. *J. Mammal.* **55**: 475–77.
- Woodall, P. F., 1986. Mammals at Kroombit Tops, central Queensland. *Qld Nat.* **27**: 76–79.

BOOK REVIEWS — BOOK REVIEWS

“Biodiversity: Australia’s Living Wealth”
ed by A. J. Beattie, 1995.
Reed Books Australia, Chatswood, NSW.
131 pp. RRP \$29.95. ISBN 0 7301 0482 6.

This is an absolutely marvellous book for people without a biology background to learn about biodiversity and its importance to the survival of our world. I believe that it is also very useful to biologists because the concepts of biodiversity are well laid and are summarized in a clear manner. One of the stated purposes of this book is to introduce the science of biodiversity in the hope that increased understanding of its foundations will lead to informed debate and wider consensus. The science of biodiversity is relatively new and its vocabulary may be unfamiliar. After reading *Biodiversity*, one will get a good background in principles and terminology.

The book starts with clear-cut stated purposes and is followed by a stimulating forward by Professor Paul Ehrlich, Stanford University, one of the world’s most distinguished population ecologists. The preface, written by Professor Beattie (Research Unit for Biodiversity and Bioresources, Macquarie University), provides a wonderful lead into the book. He presents amazing figures to document how much of the flora and fauna of Australia are unique. I soon found that there were terms that I had not heard of before such as “megadiverse nation”, “keystone species” and “ESD”. But there is a glossary that provides easily understood definitions of terms that may be new to a reader.

There are nine chapters and each has many excellent and informative photographs and illustrations. There are additional references given at the end of each chapter for the reader to pursue. Scattered throughout the text are boxes of associated information that makes for interesting and informative browsing. Chapter 1, *What is Biodiversity*, is an introduction to this new field and clearly explains the three levels that it operates: species diversity and how species are named, genetic diversity and ecosystem diversity. There is an excellent illustration on page 15 that dramatically shows the levels of diversity in a small

habitat, in this case a mangrove swamp. Chapter 2 covers the origins of biodiversity. This gives a good overview into the forces that shaped the development of life. For instance, the information box on page 30 gives a clear and graphic demonstration of species richness. There is an interesting section on human impact on evolution.

Chapter 3, *Biodiversity and Bioresources*, considers biodiversity as a valuable asset that can be used for us or can be damaged in a way that affects the economy and environment. Sections on the value of wild genes to agriculture, biodiversity-based industries and future biological resources particularly drew my attention — spider silk used for bullet proof vests — amazing. Chapter 4 gives a brief review of animals and plants and their amazing diversity of forms and exploitation of habitats. Chapter 5, *The Microscopic Life Forms*, discusses the many life forms, found from air currents to the deepest ocean trenches which are unknown to many people. I have never seen two subjects discussed before — the economical importance and the conservation of microbial biodiversity. It is fascinating reading and is accompanied with superb photographs.

Chapter 6 covers worldwide patterns of diversity and includes sections on the effects of altitude and latitude, biodiversity of islands and ocean environments amongst other interesting topics. An informative diagram of the biomes of the world is found on page 70. Many readers will be particularly interested in Chapter 7, *Australian Biodiversity*. There is a very worthwhile coverage of the diverse life in Australia, its origins, the variety of organisms, the radiations of some groups and unique ecosystems. Chapter 8 discusses the frontiers of biodiversity. This new science has its own set of complex questions such as how many species of organisms are on this planet; which groups are still largely unknown; where will most new species be found; and why is biodiversity so hard to find. Chapter 9, *Managing Biodiversity*, takes a look at recent events that will affect the future of biodiversity. Thought provoking topics include climate change and the greenhouse effect; bioregional